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STATE OF ILLINOIS
STATE GEOLOGICAL SURVEY

FRANK W. DEWOLF, Director

EXTRACT FROM BULLETIN No. 36

CLAY DEPOSITS NEAR MOUNTAIN GLEN
UNION COUNTY, ILLINOIS

BY

STUART ST. CLAIR



PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
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CLAY DEPOSITS NEAR MOUNTAIN GLEN UNION COUNTY, ILLINOIS

By Stuart St. Clair

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INTRODUCTION

IMPORTANCE AND LOCATION OF CLAY DEPOSITS

The existence of fire-clay deposits near Mountain Glen, Union County, Illinois, has been known for many years. Development on a very small scale was attempted at a few places, and small shipments were made from time to time. Not until the European war cut off importation of high-grade German refractory clays was the economic importance of the Union County fire clay generally recognized. This clay is reported to be equal, if not superior, to the foreign clay for the manufacture of graphite crucibles and glass pots.

There are at present three producing mines in the area, and a new industry has developed which, on account of the high grade of its product, should weather the storm of competition when it is again possible for the importation of European fire clays.

The area in which the clays are found is in the northwestern part of Union County, less than one mile southwest of Mountain Glen, which is on

the Mobile and Ohio Railroad, and about six miles northwest of Anna. The three producing properties are located in the western half of sec. 35, T. 11 S., R. 2 W. Several prospects, an abandoned mine, and an intermittent producer are in the vicinity.

ACKNOWLEDGMENTS

The writer wishes to express his thanks to Messrs. H. P. Miller, mine manager of the French Clay Blending Company; F. B. Harriman, president and manager of the Illinois Kaolin Company; and Frederick E. Bausch, owner of the Bausch mine, for courtesies extended to him and for aid given him during the investigation of the clay properties.

GENERAL GEOLOGY

No attempt was made to study in detail the stratigraphy of the area. The section, however, includes Devonian, Mississippian, and Pennsylvanian formations. Black shales and cherts of Devonian age are present in the hills about half a mile west of the mines, a fault separating them from the Mississippian rocks which outcrop near the mines. At the big pit of the Illinois Kaolin Company, the Spargen limestone outcrops, being recognized by Weller by the presence of *Spirifer subcardiformis*, a characteristic fossil. To the north, the Chester and Pennsylvanian formations are typically developed, a northwest-southeast fault having dropped them down at a point a little northeast of the clay mines. To the south and southeast the Mississippian formations older than Chester are to be found.

In the extreme southern part of the State are deposits of sand and clay laid down in the "Gulf embayment" and assigned to Cretaceous-Tertiary time. Overlying these deposits are the sands and gravels that are referred to the Lafayette. The clay deposits of the area described in this report are thought to have been deposited in an arm of the Tertiary Gulf embayment, which extended farther north on the west side of the Paleozoic uplands than did the main embayment on the east side.

The major faulting of the region is post-Pennsylvanian in age and is thought to have taken place at about the close of the Paleozoic era. The even-crested tops of the Devonian hills west, southwest, and south of the clay mines, as well as the ridges of the Pottsville escarpment to the north and east, strongly suggest the former presence of the peneplain which may have reached its fullest development about Cretaceous time. On the hills west of the mines, chert gravels were found very sparsely distributed at elevations of more than 700 feet, and they may extend to a greater elevation.

Quaternary lake deposits are found in the valleys of the larger streams on two well-defined terraces, the higher of which does not exceed 400 feet. None of these deposits extends up Clear Creek as far as the clay mines, for the elevation at the latter is close to 450 feet.

Alluvium of Recent age is found in the flood-plain areas of the streams in the region.

CLAY DEPOSITS

CHARACTER

From a lithologic standpoint there are four kinds of clay in the area—a bluish-white, highly plastic fire clay; white, highly plastic fire clay; pink, highly plastic fire clay; and pink and white, less-plastic clays. The first two are the valuable commercial clays. All are very fine grained and contain no grit whatever except at the contacts with the underlying and overlying sands or near some sand pocket within the clay deposit.

Three samples of clay have been tested by the Ceramics Department, University of Illinois, under the supervision of Professor C. W. Parmelee. The results are tabulated below. Sample 1 is bluish-white clay taken at a depth of 58 feet from the surface, or 50 feet below the top of the clay. Sample 2 is bluish-white clay taken from a pit and was 30 feet below the top of the pink clay and 15 feet below the top of the bluish-white clay. Sample 3 is pink clay taken from the pit and was about 10 feet from the top of the clay.

SAMPLE 1

Color	Bluish white
Plasticity	Very good
Water content required.....	32.8%
Molding properties	Formed readily by hand and flowed easily through a die.
Tensile strength of dry briquets.....	124 pounds per square inch
Bonding strength, i. e., the tensile strength of a mixture of equal parts of clay and standard Ottawa sand	95.3 pounds per square inch
Slaking test, i. e., the time required for a mixture of equal parts of potter's flint and clay formed into $\frac{3}{4}$ -inch cubes to disintegrate when submerged in water at room temperature.....	21 minutes
Screen test of clay deflocculated by use of an appropriate amount of sodium carbonate gave the following residues—	
200 mesh	0.53%
100 mesh	0.21
80 mesh	0.24
40 mesh	0.04
20 mesh	0.00
Total residue	1.02%
Drying shrinkage of the clay formed into bars by forcing plastic body through a die	6.7%

Bonding strength..... 89 pounds per square inch
Slaking test29 minutes

Screen test, residues left—
200 mesh0.20%
100 mesh0.09
80 mesh0.11
40 mesh0.02
20 mesh0.00

Total residue0.42%

Drying shrinkage7.2%

Burning tests—

<i>Cone</i>	<i>Color</i>	<i>Hardness</i>	<i>Porosity</i>	<i>Shrinkage</i>
08	White	Scratched with knife	36.2%	3.0%
06	do	do	36.0	3.2
04	do	do	36.0	3.2
02	do	Steel hard	32.2	5.0
1	do	do	32.5	4.5
3	Light buff	do	21.2	8.2
5	Blue stoned	Vitreous	2.5	11.0
7	do	do	3.2	11.2
9	do	do	3.0	11.2

Fusion test.....Deforms between cones 33 and 34

SAMPLE 3

ColorDark rose pink
PlasticityVery good
Molding propertiesSoft, easily crushed; formed readily by hand.

Tensile strength of dry briquets.....95.5 pounds per square inch
Drying shrinkage5.9%
Slaking test30 minutes

Screen test, residue left—
200 mesh0.16%
100 mesh0.14
60 mesh0.10
40 mesh0.00

Total residue0.40%

Burning tests—

<i>Cone</i>	<i>Color</i>	<i>Hardness</i>	<i>Porosity</i>	<i>Shrinkage</i>
08	Pink		35.5%	3.0%
06	do	Steel hard	35.5	3.0
04	do	do	34.2	3.5
02	do	do	31.8	4.7
1	do	do	28.0	6.5
3	do	do	12.5	10.0
5	Faint pink	do	6.5	10.0
7	Grayish white	do	2.8	10.0
9	do	do	3.6	10.0
10	do	do	3.6	10.0

Fusion tests.....Deforms between cones 33 and 34

These tests show similar pyrometric qualities as have already been reported for clay samples which were taken from pits in the mountain Glen district many years ago¹. (These early tests are given on page 175 of Bulletin 4, Illinois State Geological Survey). Chemical analyses of the old samples are tabulated below. Sample D 10 was taken at a depth greater than 50 feet; D 11, 40 to 44 feet in depth; D 12, 35 to 40 feet in depth; D 13 and D 14 were taken from the stock crib and represent the beds from the top of the deposit to a depth of 20 feet.

Sample	Moisture	Volatile	SiO ₂	Fe ₂ O ₃	Al ₂ O ₃	TiO ₂	Total per cent
D 10	1.25	9.90	43.90	1.76	40.79	2.40	100.00
D 11	0.97	15.37	48.30	1.02	31.14	3.20	100.00
D 12	0.86	8.64	56.55	1.23	29.97	2.75	100.00
D 13	0.90	9.05	47.95	1.23	37.86	3.01	100.00
D 14	0.87	10.61	52.65	0.97	33.98	2.92	100.00

From the mechanical and pyrometric tests made upon Samples 1 and 2, bluish-white clay, the following statement may be made concerning the uses and commercial qualities of the clay. We quote Mr. C. W. Parmelee of the Department of Ceramic Engineering, University of Illinois.

This material is a very fine-grained, plastic, strong, highly refractory clay well suited for use as a bond clay in the manufacture of high-grade refractories. Although its properties are not quite the same as those characterizing the European bond clays heretofore extensively imported for use in the manufacture of graphite crucibles, crucibles for brass meltings, and other purposes, yet this clay approaches so nearly as to warrant the belief that it may be used for these purposes.

The clay may be used also where a good bond clay is required, as, for example, in the manufacture of chemical stoneware. It also seems to be possible that further experiments may show that this clay may be substituted in certain products for ball clay, providing that the dark color developed by these clays at the higher temperatures is not objectionable.

As stated in the introduction, these clays are being satisfactorily used in place of the European clays in the manufacture of graphite crucibles and glass pots.

In regard to the commercial qualities of the pink clay, Sample 3, Mr. Parmelee says:

This clay is similar to clays 1 and 2 (bluish-white) in being a highly refractory bond clay and is suited to the purposes previously mentioned. It should be noted that this clay differs slightly with respect to the cone temperature at which it first attains its minimum porosity. Clays 1 and 2 show a minimum porosity attained at two cones lower than clay 3. This characteristic is likely to render clays 1 and 2 better suited to use for graphite crucibles.

An unusual feature of this clay is the retention of a pink color (lilac at the higher temperatures) up to cone 5. This is most unusual, and a chemical analysis of the clay would be of much interest.

¹Purdy, Ross, and DeWolf, F. W. Illinois fire clays: Ill. State Geol. Survey Bull. 4, p. 175, 1907.

It is our opinion that the color of the clay does not affect its intrinsic value for the purposes mentioned and that any method of decolorizing the clay would be prohibitively expensive and of no real advantage.

OCCURRENCE OF CLAYS

The fire clays occur in bedded deposits, are underlain by sand, and overlain by sand, gravel, and in places an iron-cemented conglomerate.

In general, the covering is loess, the thickness of which varies from a few feet to 15 or more. Directly underlying the loess is a bed of water-worn gravels which are sub-angular to rounded, the size of the pebbles varying from a fraction of an inch to three inches in diameter. The thicknesses of the gravel beds vary from three inches to nearly two feet in the hillside deposits and up to eight feet in the deposits which are found in the lowland bordering the east branch of Clear Creek.

In typical exposures white and pale red, fine-grained, micaceous sands underlie the gravel bed and have a maximum thickness of about 20 feet. This deposit is thin or absent in places. Underlying the sand is the fire clay. In the large pit of the Illinois Kaolin Company the upper part of the fire clay is pink and the thickness 15 feet. Beneath the pink clay is a very thin bed of white clay at the west end of the pit, which thickens to 10 feet toward the center and east side. Bluish-white clay is below the white and in places has a workable thickness of 40 feet or more. In some pits as much as 17 feet of clay and lignite underlie the bluish-white commercial clay. Below this a white or red water-bearing sand is usually encountered.

Occasional sand lenses are found in the clay bodies and there are places where for a small thickness the clay may be sandy; the latter condition is especially true near the edge of a deposit. However, on the whole, the clays are quite free from sandy impurities. Pockets of refractory clay may be found in places within the sand beds that overlie the main clay bodies. This relation may be seen at the pit of the Illinois Kaolin Company. In a few places the upper part of the white or bluish-white clay has been stained by the action of surface waters, a light-brown to chocolate color probably being produced by organic acids, a pale red mottling probably being caused by iron solutions.

Lignite is present in small quantities in the bluish-white clay. The greatest amount is in the lower parts of the deposits and may make considerable quantities of the clay unfit for marketing. In one shaft of the French Clay Blending Company the drill showed the lower 17 feet of the deposit to be lignite and clay. Wherever small pieces of lignite are found, or where a piece may have lain, the clay is stained a dark chocolate color, the amount of clay discolored depending upon the original size of the woody piece. These streaks are in all positions, vertical, inclined, and horizontal, a fact which strongly suggests that the original vegetable matter was washed into the depressions along with the clay. The present practice of discarding the

lignite-stained clay should be discouraged. At the high heat to which this clay is subjected in most of its commercial usages, the organic stain should entirely disappear.

There are a few small prospects located well up on the hillsides. The relations existing at these deposits are partly obscure owing to the small amount of development work done. Some of the conditions of occurrence are similar to those found at the main deposits, but the clay is apparently of different quality. It is not very plastic and resembles more a pottery clay. The color is pink and white, and the texture is fine grained. Gravels overlie the deposits.

The basement of the deposits has never been determined, by drilling, but the writer suggests that it is very probably limestone. Only one exposure of the wall rock was observed. This outcrop was about 300 feet southeast of the big pit of the Illinois Kaolin Company and was of Spargen limestone. Other outcrops of limestone may be seen near some of the other deposits, and it is the opinion of the writer that the clay deposits occupy depressions in a limestone area.

In at least one deposit the pink clay attains considerable thickness, a shaft on the Goodman property having passed through 93 feet. However, the surface elevation of the top of the pink clay of this deposit is very much higher than it is at the other deposits. Of special interest and a feature that may be of considerable importance in further prospecting is the elevation to which the bluish-white clay extends. If we consider only the deposits of tested high-grade fire clay, the highest elevation of the bluish-white and white varieties is about 470 to 475 feet above sea level. Other clays in the vicinity extend about 100 feet higher, but they are apparently of a different grade.

ORIGIN OF CLAYS

From a study of the geologic occurrence of the clay deposits, the sedimentary origin of the large deposits in which lignitic material is found is obvious. In the smaller deposits, wherever it is possible to study conditions, the occurrence of the clay as well as the underlying and overlying sand and gravel beds can be explained only by sedimentary deposition. However, the presence of large faults, and probably some smaller ones, suggests the possibility of finding some clay along one or more of the fault planes as an alteration product. The less-plastic clays found on the hills west of the mines may belong to this class.

The geologic processes that operated and the conditions that obtained during the accumulation of the sedimentary deposits found in and around the clay mines may be stated in a short chronological history of events that must have taken place in the area.

The great Gulf embayment, which spread over much of the south-central part of the United States during Cretaceous-Tertiary time, reached as far north as the extreme southern end of Illinois. Deposits of sand and clay in Alexander, Pulaski, and Massac counties are evidence of this invasion of the sea. The finding of quite similar deposits just southwest of Mountain Glen would strongly suggest that an arm of this embayment had reached the northwestern part of Union County, very probably having followed the course of some stream valley west of the Devonian highlands of Union and Alexander counties. This arm of the sea probably followed valleys the position of which approximated the present Mississippi Valley and the smaller valley of Clear Creek.

The surface of the land over which this arm of the sea extended had depressions and higher places probably quite similar to the present surface of the land in this area. Deposits of sand and clay would, therefore, fill the low places first. The thickness of sand and clay in the deposits that are being worked is such as to suggest that here deposition took place in limestone sinks.

The first deposit was sand which was followed by bluish-white clay. Considerable vegetable matter was in the depressions and became mixed with the lower part of the clay producing the highly lignitic bluish-white clay that is found in the lower part of some of the deposits. During the deposition of the bluish-white clay more vegetable matter was washed into the depressions. Following the deposition of this clay, probably without a break, the white variety was deposited. There appears to have been a break in deposition following the white-clay stage for the thickness of the latter is variable. The waters in which the pink clay was deposited evidently reached a higher elevation than during the preceding stages, for at least one deep basin was filled which had not received any of the earlier clay sediments.

Following the main clay stages red and white sand with some clay in pockets were deposited. Elevation of the land throughout the whole region at about this time caused the removal of fine sediment and the deposition of coarser material which we may tentatively classify as Lafayette.

To recapitulate, the fire-clay deposits are sedimentary in origin, the clay having been transported by water and deposited in depressions which existed in the old land surface.

RECOMMENDATIONS FOR PROSPECTING

If the origin as outlined is correct then we may expect to find clay bodies only where there were depressions in the land surface over which the waters of these early times extended. The favorable places for deposition would be in small embayments where the movement of the water would

be so slight as to allow the fine clay material held in suspension to settle, yet where fresh supplies could be continually introduced. Such conditions as these would probably not obtain along the main arm of the sea. Therefore, in the smaller reentrants we should expect to find clay deposits commensurate with the size of the surface depressions into which the clay could settle.

As has already been pointed out there is a fault a short distance east of the mines which brings the sandstone, shale, and limestone formations of the Chester in contact with the soluble limestones of the lower Mississippian in which area the present known clay deposits occur. About half a mile west of the mines faulting has caused the Devonian shales and cherts to form the surface rocks. It is the writer's opinion that the large depressions into which the clay material could settle existed in the area of soluble limestone rocks between the two faults, these deep depressions being sink holes, and that probably only small depressions existed in the less soluble rocks outside the central fault block.

If these deductions are correct, the large clay deposits will be confined to a relatively small area, although somewhat larger than that already exploited, and the commercially valuable fire clays will probably not be found at a present elevation much greater than 480 feet above sea level. However, smaller deposits may be found outside this area, and prospecting for them should be encouraged, should the present demand for high-grade refractory clays continue.

The limiting of the present field as a result of geologic study in this small area should not be interpreted to mean that there are not good chances of finding large deposits in other parts of the region. Wherever an arm of the Gulf embayment may have reached an area underlain by a prevailingly soluble limestone, and where conditions were favorable for the deposition of clay material held in suspension, other large clay deposits may have formed.

DESCRIPTION OF CLAY PITS

ILLINOIS KAOLIN COMPANY

The large pit, designated as "K" pit, of the Illinois Kaolin Company (fig. 2) is located in the SW. $\frac{1}{4}$ sec. 35, T. 11 S., R. 2 W., and is about a quarter of a mile west of Kaolin Station on the Mobile and Ohio Railroad. The pit has dimensions of approximately 150 by 200 feet and is about 80 feet deep at the west end. A section at the west end of the pit shows the following succession.

Section from "K" pit of Illinois Kaolin Company, SW. $\frac{1}{4}$ sec. 35, T. 11 S., R. 2 W.

Description of strata	Thickness Feet
Loess at top	..
Gravel bed	1
Sand, white, micaceous; in places stained pink.....	10
Sand, pink to dark purplish red, micaceous.....	10
Clay, pink to red, highly plastic.....	15
Clay, bluish white, highly plastic.....	15

At the southwest corner is a pocket of pink and white clay, slightly sandy, which occurs in the sand beds overlying the main clay body. At the east end of this pocket is an irregular iron-cemented conglomerate bed. On the north side of the pit is a small fault that runs approximately east and



FIG. 2.—Pit of Illinois Kaolin Company.

west. Along the fault plane is an iron seam and altered clay of a purple color. The south side is the downthrow, and the displacement is probably not more than 15 feet.

The clay is mined with two steam shovels and is hauled from the pit by a small engine. The cars containing the clay are run to a shed about 300 feet east of the pit, and unloaded on a platform where it is cleaned by hand. A switch from the railroad to the platform facilitates shipping. A large shed was erected in the fall of 1916 with a storage capacity of 5,000 tons. A drying plant is on the property but is not being used.

The company's property included three other pits none of which was being worked when the writer visited the district in October, 1916. About a quarter of a mile west of the big pit is an abandoned shaft 20 to 25 feet deep, known as "G" pit. It is claimed that there are 40 feet of white clay

with a little pink on top which is almost non-plastic. In this respect the clay differs greatly from the clays of the main deposit, which is about 100 feet lower in elevation.

About a sixth of a mile northwest of the big pit is a shaft known as "F" pit, from which pink and white, partly plastic clay was taken. The clay body is said to be 50 feet thick and to be underlain by red sand.

A little north of the big pit is the location of the earliest clay mining in the district, which was carried on by Dr. Goodman of Cobden. Pink, white, and bluish-white clay was mined from a shaft said to have been 75 feet in depth.

FRENCH CLAY BLENDING COMPANY

The property of the French Clay Blending Company is in the NW. ¼ sec. 35, T. 11 S., R. 2 W. All the mining on this property has been done in shafts. At the present time two shafts are being operated. They are 77 feet apart from end to end, and drifts are being run so as to connect the two. What is known as shaft No. 3 has a depth of 39 feet. Shaft No. 4 is 59 feet deep and passed through the following material.

Log of shaft No. 4 of French Clay Blending Company

Description of strata	Thickness
	<i>Feet</i>
Soil	2
Gravel	7
Clay, brown, highly plastic.....	14
Clay, bluish-white, highly plastic.....	36
Clay mixed with lignite.....	7
Sand, white, water bearing	..

A small thickness of mottled pink and white clay was encountered in the two abandoned shafts, extending below the gravel.

The two operating shafts are two-compartment shafts with inside dimensions 6 by 12 feet. They are well timbered from the top down to the lowest level. The drifts are also heavily timbered up to the working faces. The clay was hoisted in buckets by horse power at the time of the writer's examination, but a steam engine for hoisting is to be installed.

The company has constructed a gravel road between their mine and Mountain Glen, over which the clay is hauled to the railroad for shipment to their refining plant at Effingham, Illinois. There the clay is dried on shelves under which are steam pipes; then is handpicked, and crushed. The clay is marketed in sacks.

FREDERICK E. BAUSCH MINE

The Bausch clay mine is located approximately in the center of sec. 35, T. 11 S., R. 2 W., and just north of Kaolin Station. All mining is done by shafts and drifting to connect the shafts. There are three shafts, two

one-compartment and one two-compartment. At the time of examination there were three levels, the first at 20 feet, the second at 27 feet, and the third at 34 feet; lower levels were planned. The shafts and levels are heavily timbered. Hoisting is done by steam and windlass at present, but it is the owner's plan to electrify the mine in the near future. The clay is cleaned by hand in a shed before shipping.

The following is a section through the deposit.

Log of Bausch shaft, center sec. 35, T. 11 S., R. 2 W.

Description of strata	Thickness <i>Feet</i>
Alluvium	4
Gravel and alluvium.....	4
Clay, brown to chocolate color.....	3
Clay, bluish-white, highly plastic.....	23+

GOODMAN PIT

The pit owned by Dr. Goodman is located in the NW. $\frac{1}{4}$, sec. 2, T. 12 S., R. 2 W. All the clay taken from this deposit is of the pink variety. In spots it has a purple mottling. The clay is mined by a shaft which is immediately abandoned when the bottom of the deposit is reached. Mining is carried on only when there is a demand for a carload. Most of the clay is shipped to copper companies in the Lake Superior region, where it is used in lining retorts.

Log of Goodman shaft, NW. $\frac{1}{4}$ sec. 2, T. 12 S., R. 2 W.

Description of strata	Thickness <i>Feet</i>
Loess	10
Gravels	1
Sand, reddish brown, argillaceous.....	2
Clay, pink with purple spots, plastic refractory.....	93
Sand, red, fine grained.....	15+

ABANDONED PITS

There are a few abandoned pits and prospects in the area. The one which was probably the most important is in the NE. $\frac{1}{4}$ sec. 3, T. 12 S., R. 2 W. From appearances there evidently had been considerable mining at this point some years ago. At least two shafts were sunk and a platform 15 feet high and 30 by 30 feet built. The only clay seen on the ground was pink in color.

